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Pioneering the Endless Frontier

Science and Technology for National Security
The Next 50 Years

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Making History
Making a Difference
1952-2002

Over the Next Fifty Years

What are the national security implications

Of Trends in Science in Technology

With more Intense Globalization?

- How will we define National Security?
- How would Globalization be more intense?
- How will S&T have changed?

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Making History Making a Difference

1952-2002

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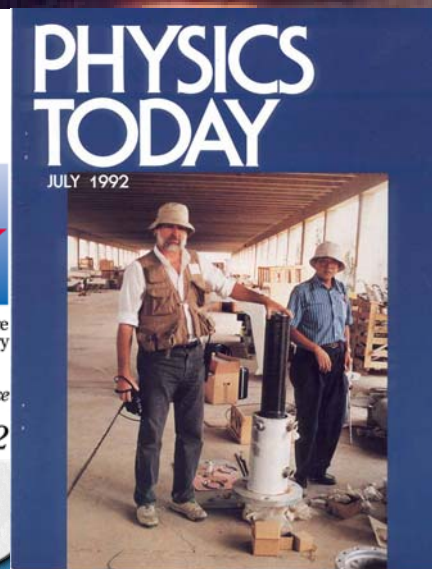

Pioneering the Endless Frontier

Science and Technology for National Security
The Next 50 Years

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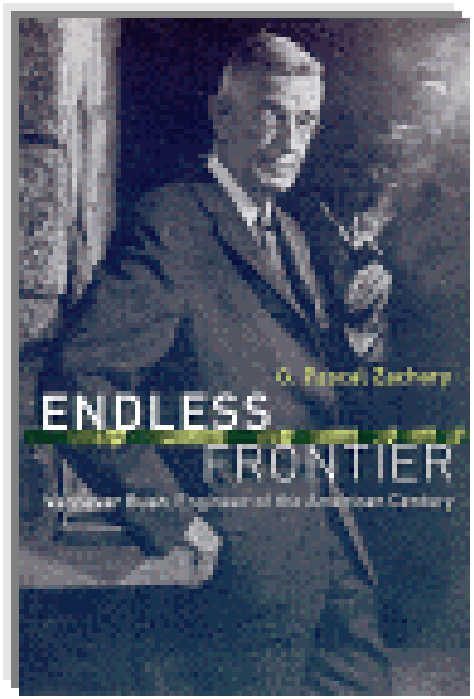
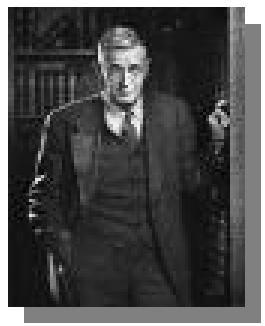
In 1945, Vannevar Bush characterized science as the “ Endless Frontier ”



President Roosevelt asked Bush to address the post-war structure of scientific endeavor

- What, consistent with security, can be done to tell the World as much as possible about scientific advances from the War effort?
- What can be done to organize a continuing war against disease?
- What can the government do to properly aid research in public and private organizations?
- Can an effective program for discovering and developing scientific talent be proposed to assure a high level of future research?

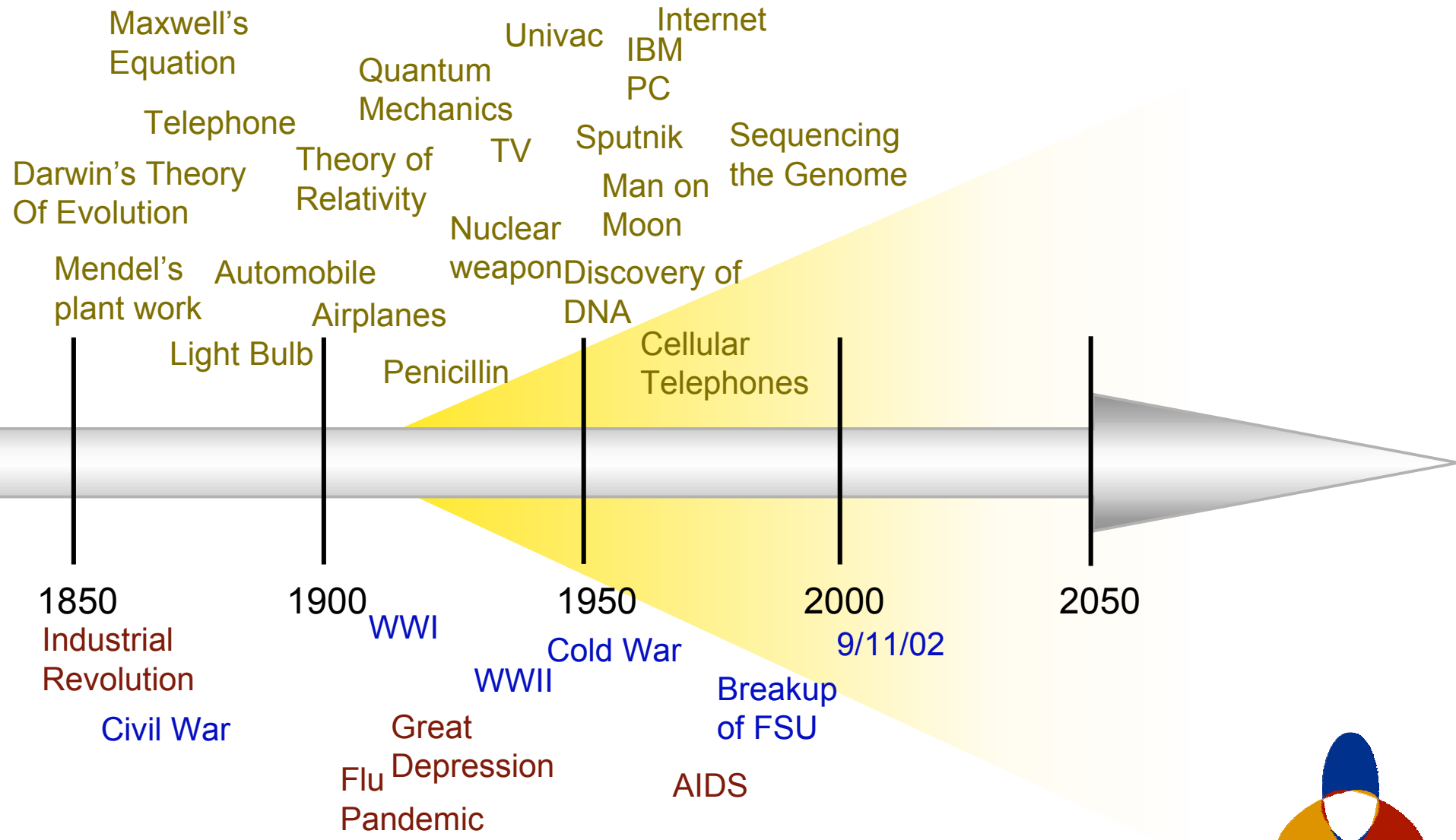


Bush's principal recommendations to President Truman were:

- Speedy release of all possible information
  - And special care for academic freedom
- Aid to industry could best be accomplished by
  - Funding basic research
  - Clear tax status of R&D expenditures
- Industrial and governmental science would best be served by
  - Funding science education

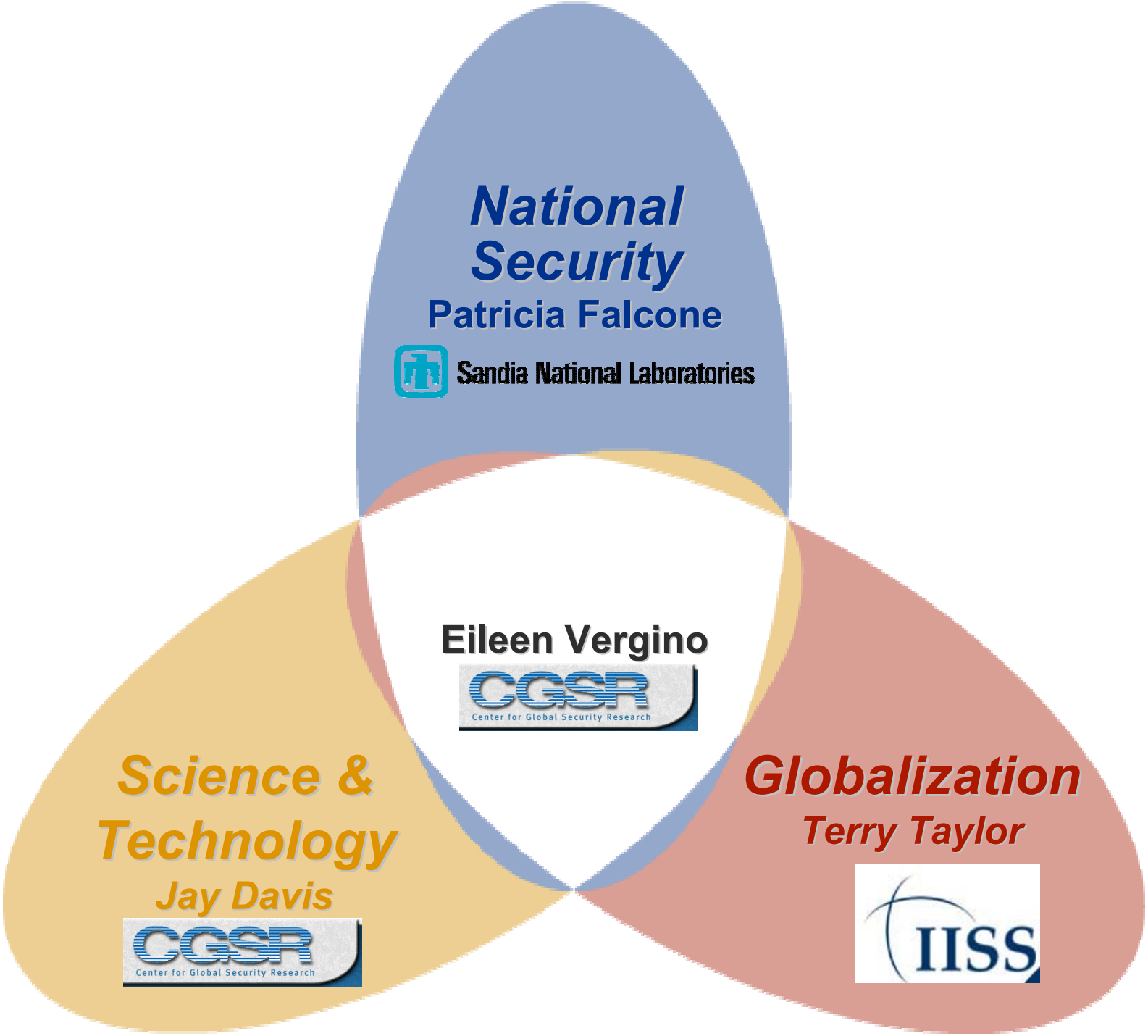
- Education must
  - Reward ability
  - Assure excellence in all disciplines
  - Preserve the generation in uniform
- Bush proposed essentially a "Department of Science"

We are in another period of transition



In an increasingly globalized world, what are the implications of transformational developments in science and technology for national security over the next 50 years?

We examined three principal themes


National Security
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Science & Technology
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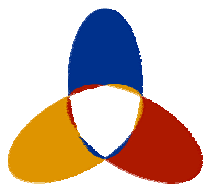
Globalization
Terry Taylor
IISS

Globalization

Terry Taylor



Globalization is:

- Transnational flow of goods, money, ideas, lifestyles and cultural values
- Not a new phenomenon

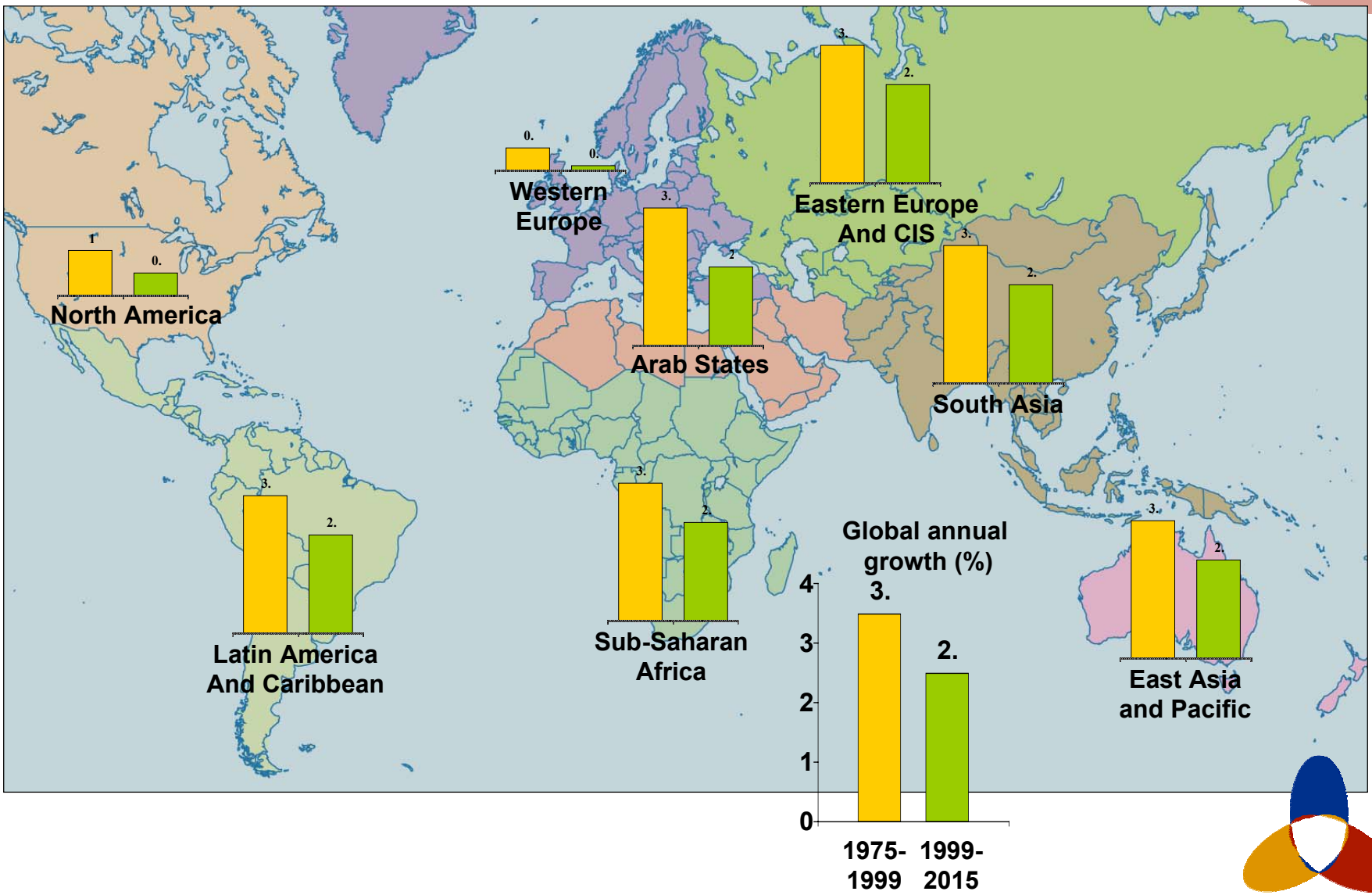
But what is different:

- Pace of change continues to accelerate
- Ever more deep and extensive - Unstoppable
- Public safety and security as a continuum
- Changing nature of alliances and groupings
- Balance of power and influence shifting from government to private sector

Demographic Transformation

- Population Growth – slowing
  - 1975 3%
  - 2015 2.5%?
- Rates of growth vary according to:
  - Region/country (population collapse?)
  - Political, economic, cultural factors
  - Disease
- Quality of life issues
  - Life expectancy and aging

Global annual population growth, 1975-2015



Migration

- Era of mass one-way migration largely over
- Multi-directional migration becoming the pattern of the future
- Concept of allegiance becoming ever more diffuse

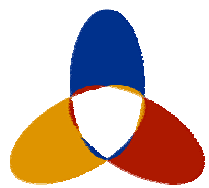
South Asian Migration - 19th - 20th Centuries

South Asian Migration - 21st Century

Diasporas -

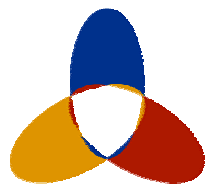
- Connecting elements include religion, language, and culture - even shared interests and lifestyles
- Key reinforcing component is a flow of financial resources
- The rate of absorption is affected both positively and negatively
  - Can be a bridge – or reinforce divisions
- Empowered by advances in transportation, communications and information technology

- networks of networks



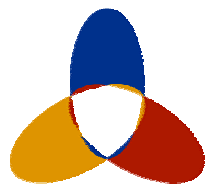
Transnational Commerce

- Leading edge for dissemination of technology
- National and international regulation falling further behind the pace of development
- Non-governmental organizations and networks will be increasingly influential
- A recent and significant example is the evolution of the Biotechnology industry
  - Biotechnology provides enormous benefits and can enhance public safety and security
  - Carries with it serious security risks and ethical concerns



Public reaction to the globalization process

- Increasing concerns about:
  - Impact on the environment
  - Challenges to public health
  - Political and economic transformation
- Reactions include various anti-globalization movements
  - Interconnectedness does not necessarily result in integration
  - NGOs challenge traditional notions of democratic processes
- Timescale of scientific and technological development does not match that of social and political change

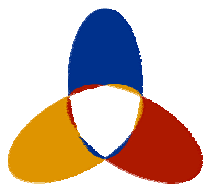


Trends at the interface of Globalization and Science and Technology

- The leading edge of transformational developments in science and technology is:
  - Embedded in the multinational/international networks of networks
  - Increasingly in the private sector
  - Creating new coalitions between the private sector and academia
  - Altering the character of the relationship between governments and the private sector
- Advances in communications and information technology:
  - Magnify power of individuals and small groups with differing interests and objectives
  - Create more diffuse centers of excellence
  - Result in even more complexity
- Both economics and regulation are leading to:
  - More mobility of R&D activities and talent
  - Flight of controversial research off-shore

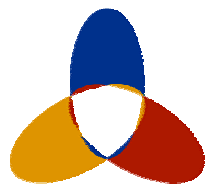
Science and Technology

Jay Davis



We began assessing the future of S&T by answering the following questions

- To what areas of science would we devote our passion, resources, and years of our lives?
- What do we wish to accomplish in or with science?
  - Where is technical or societal benefit in our work?
- How will (or might) S&T evolve in the next decades?
- What changes in the environment around us might impact what we do?
  - Including ethics, behavior and public trust
- What are the attributes of a successful S&T organization in the future?



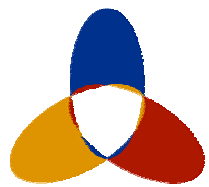
We found passion for the future in both disciplines and mission areas

- Life Sciences
- Materials Science
- Chemistry
- Information technology
- Photonics
- Climate Change
- Energy
- National Security
- Education

A danger in our process is that it can miss both disruptive technologies and unexpected discoveries

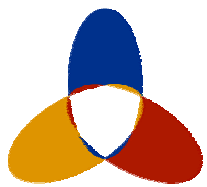
We can identify an area of possible surprise - conception of self

- Discoveries in genetic engineering brain function and evolution, could challenge humans' perception of self and what it means to be human
  - The impact of these discoveries could be more profound than those of Galileo, Darwin, Einstein
- These changes in self-conception could cause societal upheavals, dwarfing those of globalization or climate change
- We should assure that the rate of translation of discovery into common understanding can match that of discovery itself



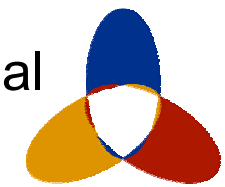
We see a rich intellectual future for S&T and its organizations

- We are dealing with complex systems using a progressively more mature mix of characterization and simulation
  - Life and Earth Sciences -- both natural and human impacts
  - The “first principles” modeling of systems in biology, materials sciences and nuclear weapons
- Investments in additional disciplines are needed to understand human behavior and impacts on humans
  - Archaeology, and evolution because they influence a vision of ourselves
  - The climate and geologic records because they contain non-human threats and limits
- Networking and connectivity will play a larger role in science
  - Successful S&T organizations will be interdisciplinary and multinational/international
  - We can have national security but not national science



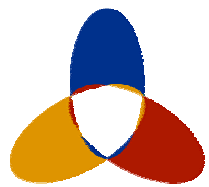
Of concern are the ethical and perceptual issues of science

- Just as in the physical sciences, the life sciences have lost their innocence
  - Fraud has become uncomfortably common
  - There have been ethical insults and personal injury
- The larger population is less sure that the products of science are good or believe that scientists are disinterested
  - Integrity essential when considering the economic, environmental, health and social costs of our activities
  - Important to communicate our real goals and ethics adequately, as well as live by example
- There is a lack of consideration of the unanticipated impact of good results
  - Curing cancer or cardiac disease might destroy the actuarial basis of retirement and health care programs



There are insights for investment in science and management of technology for national security

- The solution to many of our critical problems is inherently multidisciplinary
  - Stimulation of multidisciplinary activities requires different mechanisms in academia, industry and national laboratories
- There remains a strong role for the government in support of long term S&T, *i.e.*, that beyond the marketplace
  - Mission of national security not fully convergent with marketplace
- S&T organizations must be both agile in their use of staff and agile within their marketplaces and across their boundaries
  - As in the marketplace, specialization may last for the period of an assignment or project, not for a lifetime



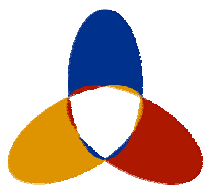
There are clear implications for National Security

- Our security will increasingly depend upon our ability to integrate technology and systems
  - This is as true for counter-terrorism as for traditional war-fighting
  - In particular, in terrorist events the event itself defines the organization chart
  - This requires technological and organizational agility
- Commercial technologies will be progressively dual use
- With progressively marginal effectiveness, we may be able to control technology -- but not science
- Emerging national security threats are not amenable to technological solutions alone
  - We will need to deal with sociology and psychology
  - And know how to trade across S&T, operational, political, and sociological solutions
- Scientists continue to be needed in policy roles and policy makers need to be better informed on S&T issues

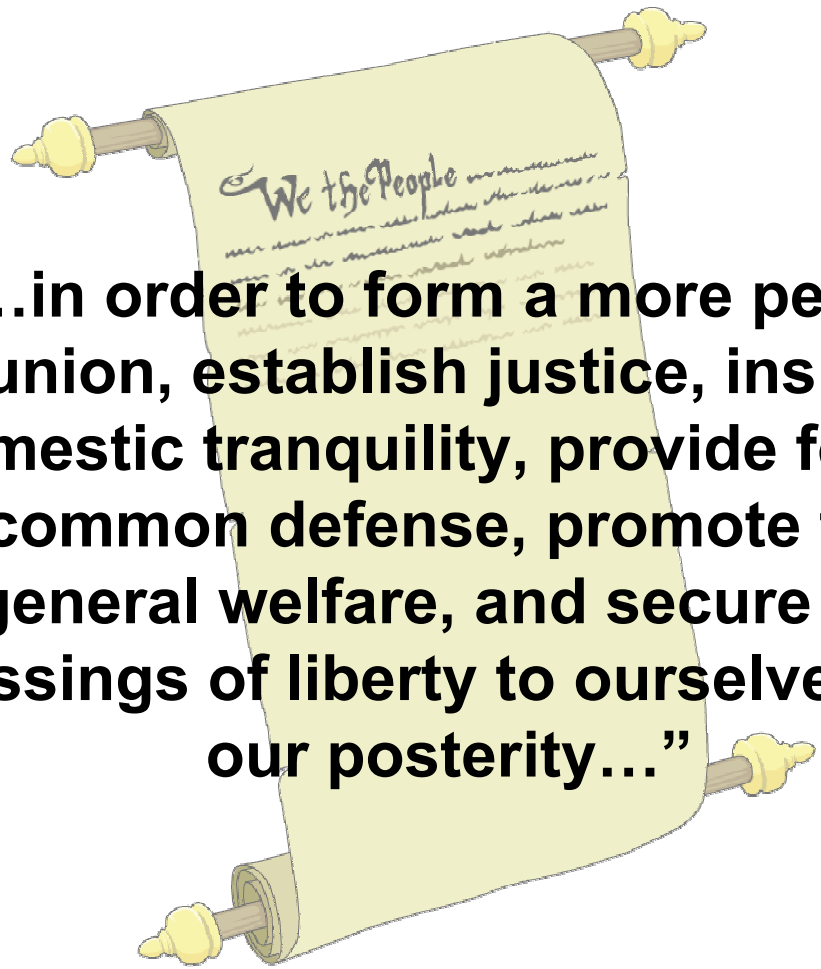
National Security

Patricia Falcone


Sandia National Laboratories



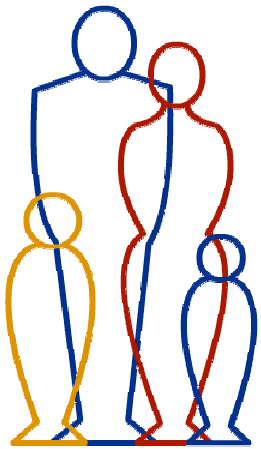
Defining U.S. National Security



"…in order to form a more perfect union, establish justice, insure domestic tranquility, provide for the common defense, promote the general welfare, and secure the blessings of liberty to ourselves and our posterity…"

Broader Dimensions of a Security System

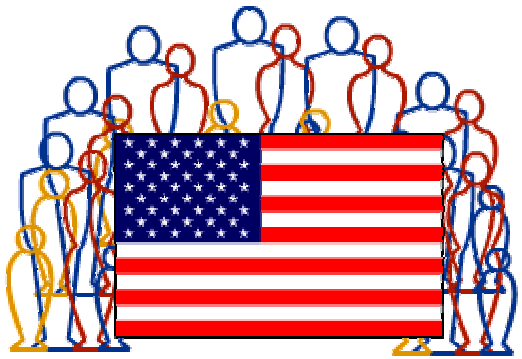
Security



Human

poverty

disease



National

crime

Global

climate change

resource depletion

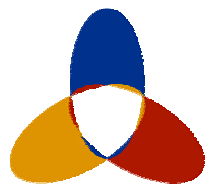
population growth and movement

A view of the future international environment

- In fifty years -
  - States will continue to dominate the international system
  - Security will continue to be an enduring concern, and a domain for federal investment and action
- Military uses of technology will remain push-pull in nature
  - Conflict produces demand for technologies
  - Scientific discoveries will create new military potential

Threats and states are transformed

- Threats come from smaller states, sub-national groups, transnational groups and /or networks among them
- Fewer people, with less expertise, can have larger effects
  - Empowered by scientific & technological developments
- Threats increasingly have ‘insider’ aspects – since ‘outsiders’ are inside
- States are increasingly multi-ethnic, with overlapping allegiances and multiple citizenships

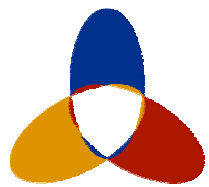


Expectations of national security are evolving

- The threat is perceived as increasingly local
  - “If the hometown is secure, then the homeland is secure”…Tom Ridge
  - Post 9/11 and into the future, national security becomes more localized, with an added dimension of “personal”, “hometown”, or “frontier” security
  - The need for local/private security results in increasing tension between privacy and security
- While the sources of threats are broader, whether natural or due to human malevolence
  - Disease and pandemics
  - Resource availability, e.g.water and energy supplies
  - Agricultural performance
  - Economic system and infrastructure

The US remains a dominant world player; there are both positive and negative consequences

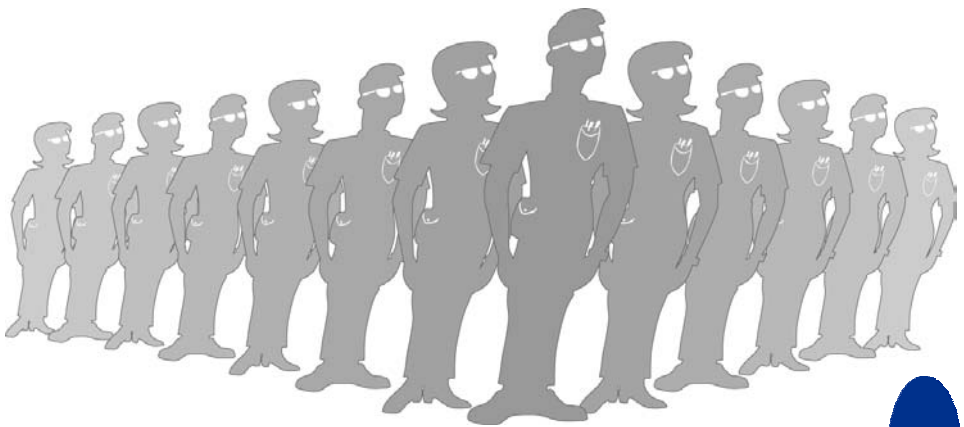
- US continues to outspend its closest competitors for military purposes
- The only player with global reach - and exposure
- Media domination
  - Culture and language
- US lifestyle and secular culture creates bonds and divisions within and across countries
- US may find itself in situations far from its borders with less certain interests and understanding



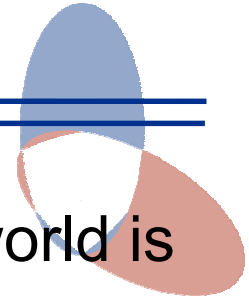
The nexus between science and technology and national security is ever more important

- It will be increasingly difficult to maintain U.S. superiority in science and technology
  - Leading edge of advancement in science and technology outside government, and geographically diffuse
  - Identifying which S&T developments will challenge national security is more difficult
  - Excellence requires investments in people, infrastructure and new ideas
- It is vital to minimize national security surprise
  - Assessment of risks must include the low-tech and marketplace as well as the high-tech

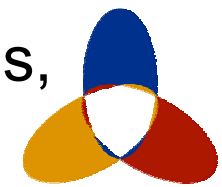
"…the nation will need "regiments of geeks" — "pocket protector brigades" who "will provide the software, systems and analytical resources" to"close the gaps Mohammed Atta and his associates revealed"

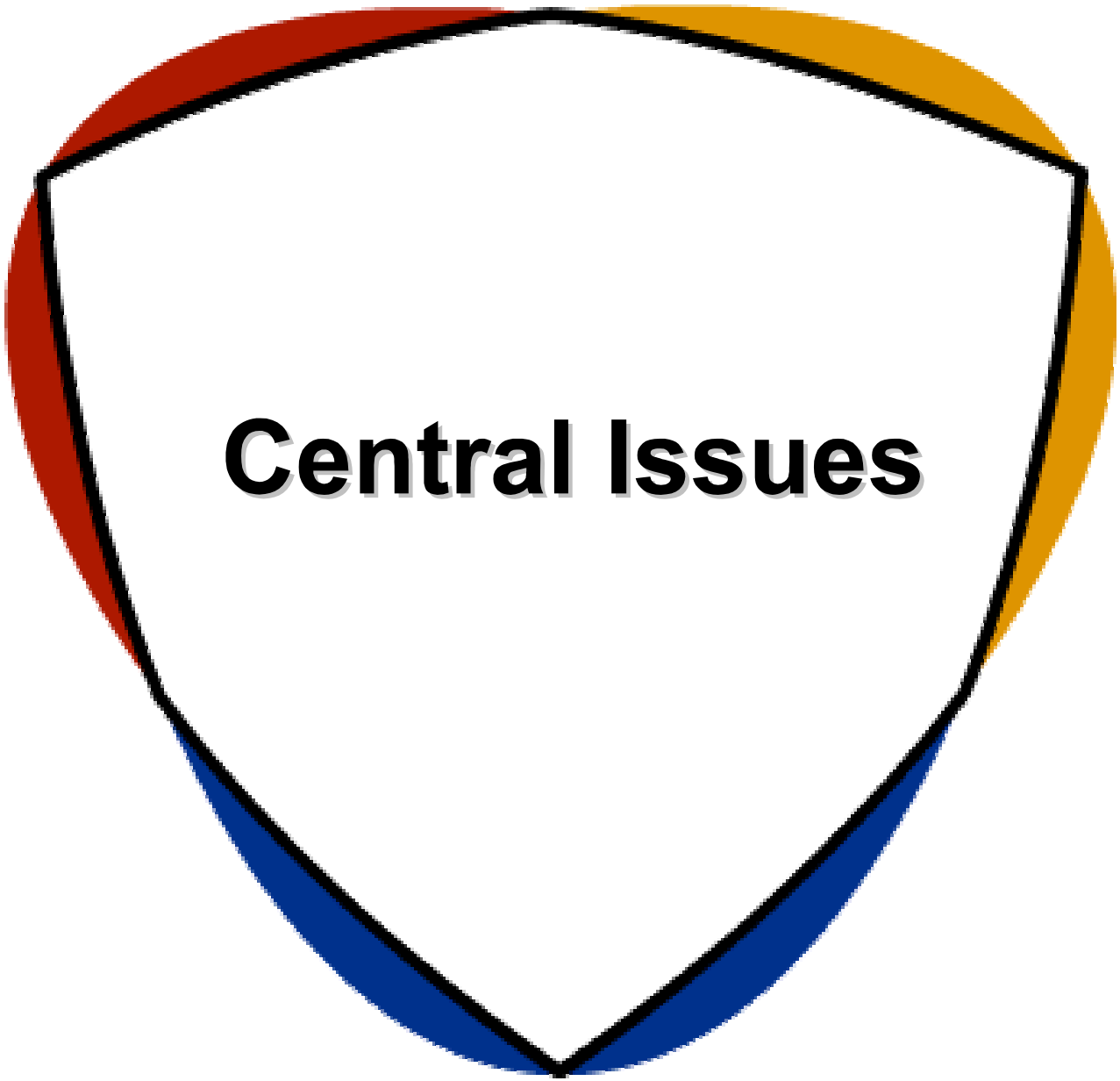


Trends at the interface of National Security and Globalization



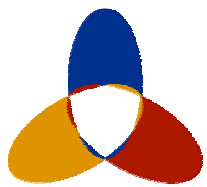
- National security in an increasingly globalized world is not about boundaries - but rather about flows
- States continue to exist but will be transformed by questions of allegiance
- International system increasingly interconnected and interdependent, facilitated in part by technology
- Aspects of globalization contribute to conflict
  - Cultural and value differences
  - Access to limited natural resources
  - Quality of life issues, including health and disease
- Demographic and planetary timescales are mismatched with political and personal timescales, and ability to change or adapt




Central Issues

Attributes of a transformed S&T system

- Agile and distributed
  - Exploit globalization
  - Anticipate new threats
  - Network and integrate across organizational and international boundaries
  - Provide expertise across project timescales and organizational evolution
- Integrated portfolio of expertise
  - Broaden disciplines, including social sciences, anthropology, psychology
  - Draw on external sources
- Implement and learn through experience
  - Build trust between entities and across boundaries



Governance of a transformed S&T system

- The system must enable linkages among best capabilities from diverse communities
  - Private
  - Public
  - Academia
  - International
- It is the government's responsibility to maintain the conditions in which the linkages and results can obtain
  - Seek optimal balance between openness and transparency and privacy and security
  - Address issues of export controls, visas and communications interoperability
  - Appropriate and timely allocation of research funding
    - Train people
    - Distributed infrastructure base
    - New ideas

We found clear messages to send:

- **To the Nation**
  - The U.S. cannot control the directions or results of science and technology
  - Discoveries have the inherent potential for both good and evil
  - We need a system of policy development that better confronts uncertainty, complexity, ambiguity, and temporal mismatch
- **To the science community**
  - Exploit the globalization processes to promote and enhance ethical norms
  - Participate in the transformation of science governance
  - Engage the public and policy makers on implications of science on society at all phases of research and development
  - Communicate clearly to others about science and technology
  - Encourage the private sector to set standards, particularly in areas of contentious research

We found clear messages to send:

- **To the national security community**
  - Opportunities and risk must be clearly communicated to the public, both with respect to national security goals as well as science and technology
  - Scientific and technical awareness are a must for decision makers
- **To our neighbors**
  - Science is important to all our lives, and our families' future
  - The scientific community needs your involvement and support
  - We must learn to live with risk and complexity

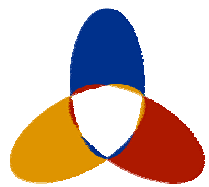
Outstanding Issues

- How to understand the tension between forces of integration and disintegration in the globalization process?
- How to reconcile the divergence between making the homeland secure and defending US interests globally?
- How best to evaluate and manage the risks so that the opportunities offered by S&T developments are not hindered?
  - Is it possible to identify indicators to help with the risk assessment – who is exploiting what, where, and for what reason?
  - How to balance the need to marginally control some technologies for some limited time while not constraining the science?
- What are the set of problems that will require transnational governance?
  - Who are the actors?
  - How do institutions adapt?
  - What form will the governance take?
- Solutions arising from science and technology require long-term investment and sustainability, yet how is the investment maintained in periods of low threat?

Appendix on the future of S&T areas

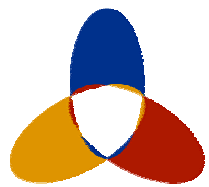
If the next Century is that of biology…

- We wish to accomplish…
  - Diagnostics adequate for healthcare and national security
  - Amelioration and cure of disease
  - A fundamental understanding of intermolecular communication
  - Designer Medicine – the ability to tailor drugs to the individual human genome
- We may have to re think the relationship between public health and national security organizations
- And manage and resource that relationship appropriately!



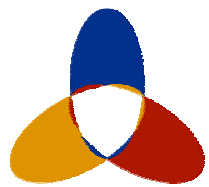
With respect to Chemistry…

- We wish to accomplish
  - Computational combinatorial synthesis
    - Coupled with effective down selection techniques
  - First principles prediction of fundamental molecular properties
    - And verification of those properties
  - Characterization of intermediate states in reactions



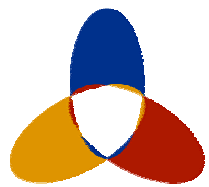
If the next Century is that of light…

- We note that data delivery rates are increasing faster than Moore's Law
  - The impact of this on all aspects of information transfer, assessment and integration will be immense
- Laser weapons will become a battlefield reality and must be dealt with
  - The opportunities are large, as are the policy issues
- This area seems rich with both hardware and software opportunities
  - The applications are in our mission areas
  - The policy issues require focused study



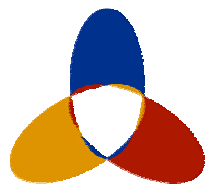
Both global climate change and regional weather prediction will be mastered

- Near term possibilities include effects mitigation and resource management
  - Storm effects and water resources
- We are nearing an understanding of climate change and tentative predictive capability for it
- We should seek to broaden the program to economic and social impacts
- DOE should reach for intellectual leadership of the national energy portfolio through understanding of both mechanisms and consequences of change



With respect to Energy Futures…

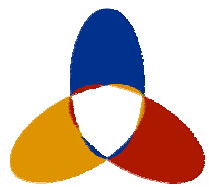
- We wish to accomplish…
  - A move away from fossil fuel consumption
  - The need to encourage conservation
  - A rational approach to alternative energy sources
  - Energy policy consistent with national security goals
  - Solving the economic, waste and proliferation problems of nuclear power



With respect to Materials Sciences…

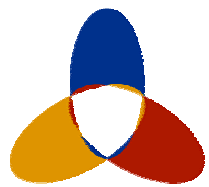
which we think ready to proceed from first principles !

- We wish to accomplish…
  - Designer or engineered materials
  - Deliberate exploitation of materials at the nanoscale
  - The ability to predict properties of materials as they age
    - For marketplace optimization
    - For Stockpile Stewardship



Lastly, we deal with information technology

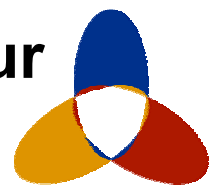
- We are aware that data is not information is not knowledge
- We would like to accomplish…
  - the efficiency, speed and understanding in manipulation of data and information that could improve our performance and productivity beyond past experience
- We note in the environment around us…
  - the possibility for unique and universal surveillance (exquisite intelligence in DoD parlance) – for both good and bad purposes
- Many possible applications of S&T (war fighting, intelligence, counter terrorism, climate change, advanced medical diagnostics, etc.) depend on pattern recognition or information regression and analysis techniques
- We feel that institutions that couple hardware and software will be essential – and successful!



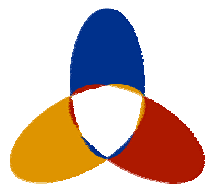
We have identified a compelling need to address education

- As practicing scientists, we are properly concerned about the motivation and education of our children and their generation
- As participants in the society, we are concerned that there will be motivated people to replace us
- We are similarly concerned that we play a role in creating a science-literate population that can effectively deal with the issues science now poses
  - We see weakness in public understanding posing a threat both to science and national security
- We struggle to know our place and role in addressing this problem – but it could offer a rich collaboration with UC!

Be aware that the most energy and passion of our sessions lies here!

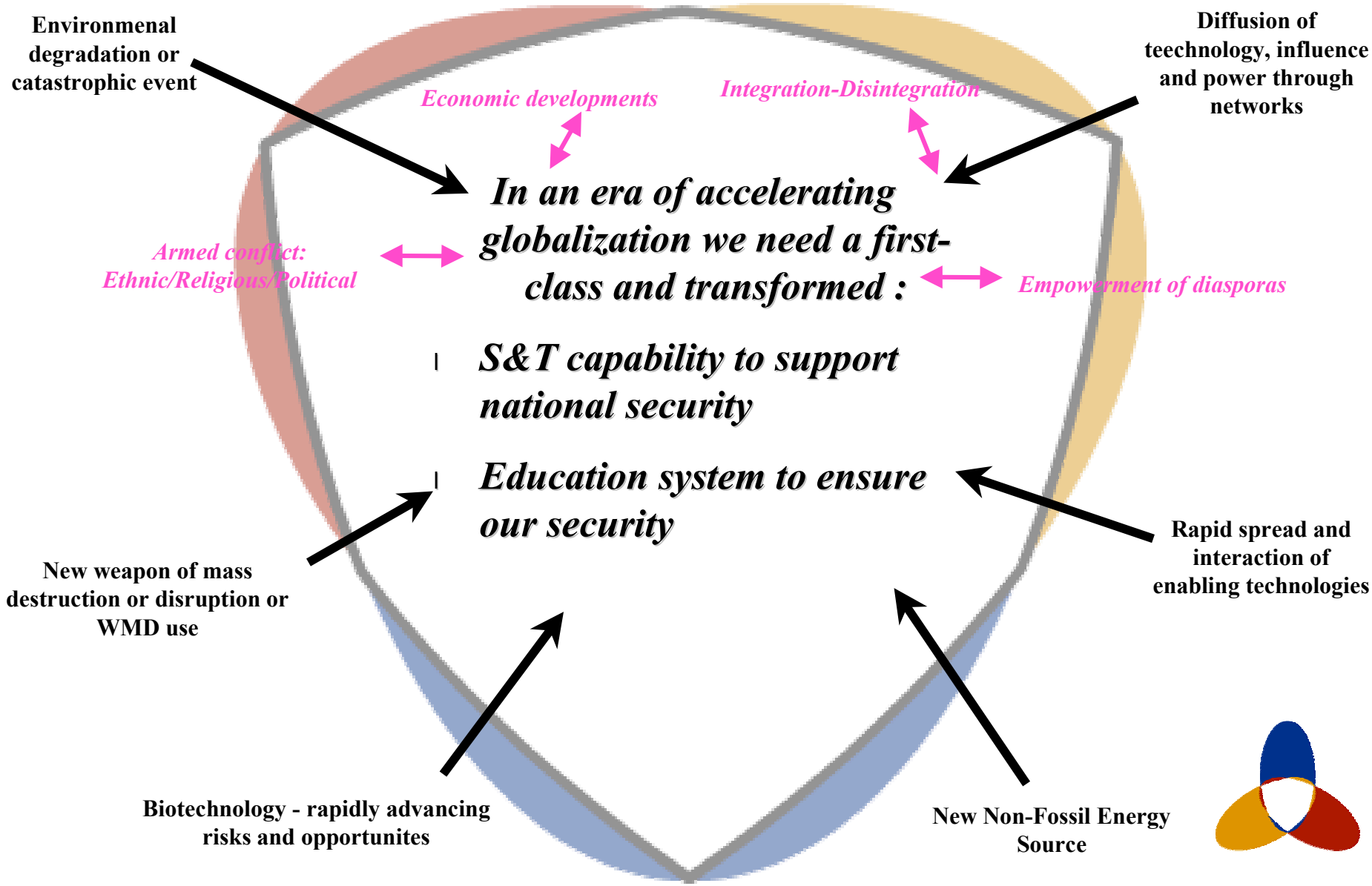


Back-up Slides

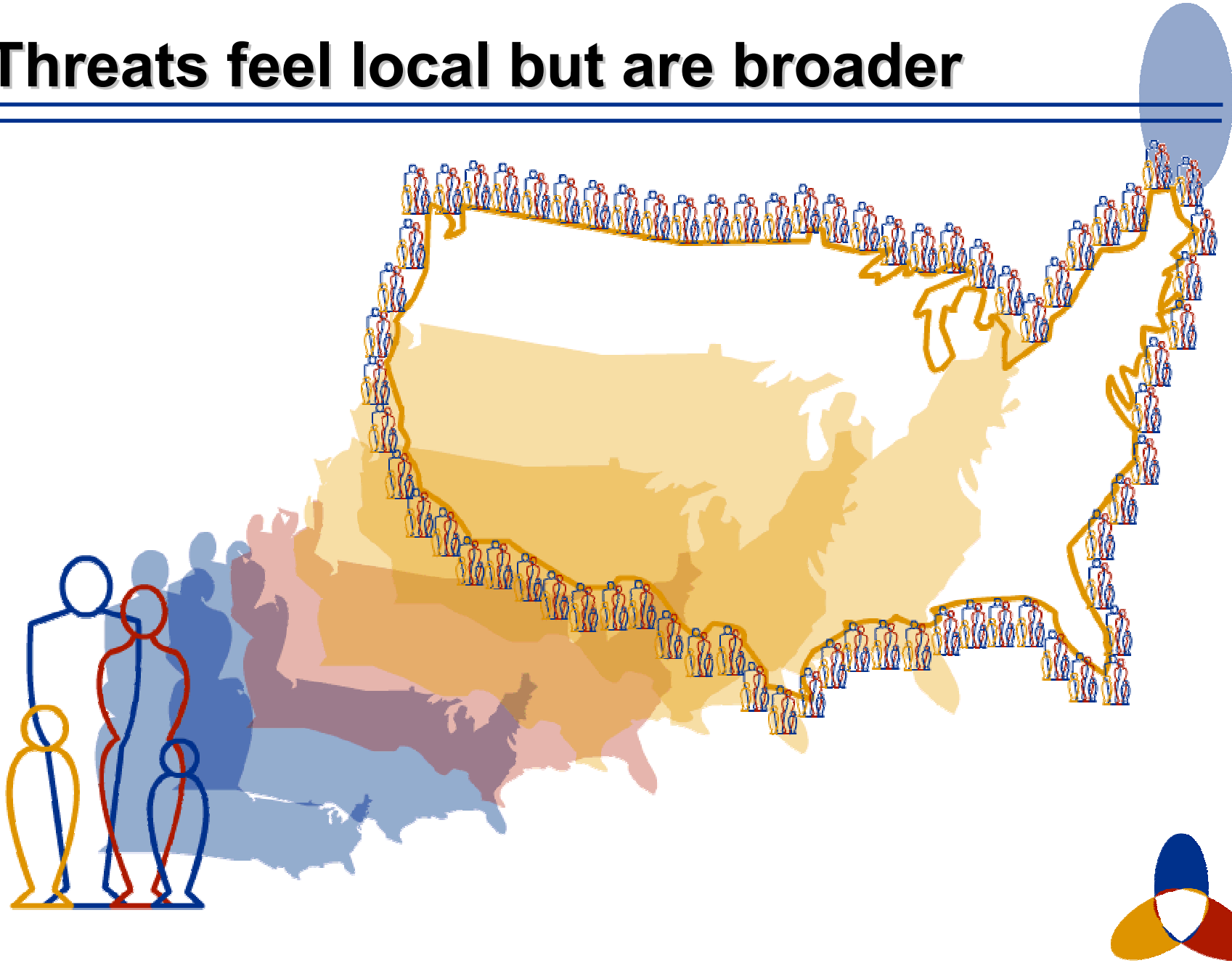


Transformational Processes

Societal Pressures



Threats feel local but are broader



Perceptions of vulnerabilities